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网络协议分析与实现

第三章典型通信协议分析


Sigtran协议 (Part I)

徐鹏


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Sigtran (Signaling Transport)



- Sigtran协议族的出现
- SCTP协议分析
- User Adaptation协议分析
 - M2UA
 - M2PA
 - M3UA
 - SUA
 - IUA



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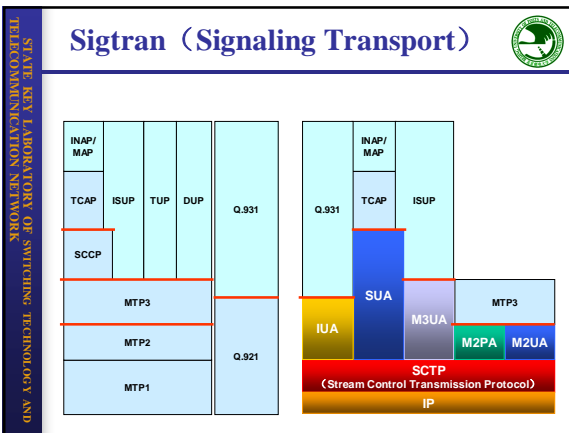


Sigtran协议族的出现

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Sigtran (Signaling Transport)

- IETF
- 定义了信令通过IP网络的**结构模型**
 - Signaling Transport over IP
- 是在IP网络中传递电话交换网络 (Switching Circuit Network/SCN) 中信令协议的**协议栈**
 - 不是一个协议, 而是一个协议栈
- **不需要**对现有SCN**信令应用**进行**任何修改**, 从而保证已有的SCN信令直接使用
- 利用**标准的IP传送协议**作为底层传送, 并通过**增加自身的** **Sigtran**是面向“传送”的协议栈



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Sigtran (Signaling Transport)

- 信令通过IP网络的结构模型
 - **通用传输层协议+专用适配协议**
 - 通用传输层协议: SCTP (Stream Control Transmission Protocol)
 - 专用适配协议
 - 关注上层应用接口
 - 的一致性

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SCTP
(Stream Control
Transmission Protocol)
协议分析

SCTP

- IETF RFC 2960 “Stream Control Transmission Protocol”

★ 如何阅读一份IETF RFC/Draft

- 为什么SCTP?
 - TCP vs. SCTP
- SCTP中引入的新术语 (Terminology)
- SCTP特性
 - 4-Way Handshake
 - Multi-Stream
 - Multi-Homing
- SCTP高层接口
- SCTP消息流程

SCTP

Network Working Group
RFC 2960
Stream Control Transmission Protocol

责任工作组

RFC序号

文档类别

作者

- IETF RFC 2960 “Stream Control Transmission Protocol”

发布日期

文档标题

文档状态说明

文档版权说明

摘要

★ 最重要的第1页, 第1页中最重要的内容是“Abstract”

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SCTP

★ 最重要的第1页，第1页中最重要的内容是“Abstract”

Abstract

This document describes the Stream Control Transmission Protocol (SCTP). SCTP is designed to transport PSTN signaling messages over IP networks, but is capable of broader applications.

SCTP is a reliable transport protocol operating on top of a connectionless packet service such as IP. It offers the following features to users:

- acknowledged error-free non-duplicated transfer of user data,
- data fragmentation to conform to discovered path MTU size,
- sequenced delivery of user messages within multiple streams, with an option for order-of-arrival delivery of individual user messages,
- optional bundling of multiple user messages into a single SCTP packet, and
- network-level fault tolerance through supporting of multi-homing at either or both ends of an association.

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SCTP

- A **reliable transport** protocol operating on top of a potentially **unreliable connectionless** packet service such as IP
 - 可靠的传送协议
 - 在不可靠的无连接的分组传送机制（如：IP）之上构建



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SCTP

- Acknowledged **error-free non-duplicated** transfer of user data
 - 无差错的传送
 - 无重复数据的传送
- **Data fragmentation** to conform to discovered path MTU size,
 - 数据的分拆
- **Sequenced** delivery of user messages within **multiple streams**, with an option for order-of-arrival delivery of individual user messages,
 - 有序的消息传送
 - 多流（Multi-Stream）特性
 - 选项：按照不同用户消息到达次序传送
- Optional **bundling of multiple user messages** into a single SCTP packet,
 - 选项：用户消息绑定
- Network-level fault tolerance through supporting of **multi-homing** at either or both ends of an association.
 - 多穴（Multi-Homing）特性

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为什么SCTP

为什么SCTP

- 在SCTP中传送信令
 - 为什么现有的协议不用于完成信令传送
- TCP
 - 面向连接
 - 可靠的数据传送
 - 严格的数据发送顺序
 - 面向"Byte Stream"
 - 在消息中需要有足够的冗余度
 - 在消息发送时需要保证
 - 端口范围受限
 - 难于支持部署于多机
 - 3次握手 (3-Way Hands)
 - Ways Handshakes
- UDP
 - 无连接
 - 不支持可靠的数据传送
 - 流量控制

虽然针对同一用户的同一呼叫的信令需要保证信令消息发送的次序，但是针对多个呼叫的信令消息则无需保证先后次序

信令则是面向"消息"的，面向消息的数据传送，维护消息边界，流间不保证次序

Multi-Stream: 流内保证次序，流间不保证次序

Msg-beginning: 一个主机使用多个IP地址，多个主机的多个IP地址

为什么SCTP

Services/Features	SCTP	TCP	UDP
Full-duplex data transmission	yes	yes	yes
Connection-oriented	yes	yes	no
Reliable data transfer	yes	yes	no
Partially reliable data transfer	optional	no	no
Ordered data delivery	yes	yes	no
Unordered data delivery	yes	no	yes
Flow and congestion control	yes	yes	no
Explicit congestion notification support	yes	yes	no
Selective acks	yes	optional	no
Preservation of message boundaries	yes	no	yes
Path maximum transmission unit discovery	yes	yes	no
Application data fragmentation/bundling	yes	yes	no
Multistreaming	yes	no	no
Multihoming	yes	no	no
Protection against SYN flooding attack	yes	no	n/a
Half-closed connections	no	yes	n/a

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SCTP术语
(Terminology)



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SCTP Terminology



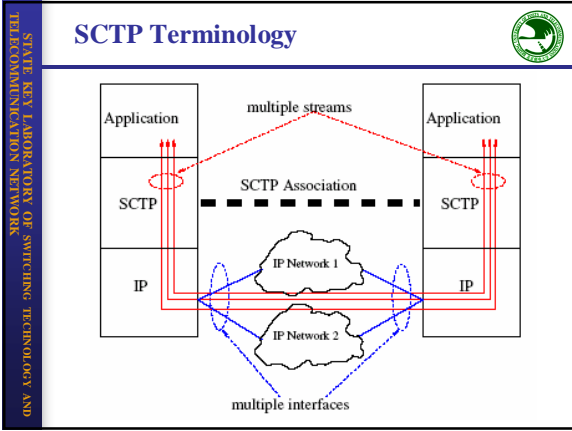
- Chunk
 - SCTP分组 (Packet) 中的一个单元
 - 组成
 - 头域 (a chunk header)
 - 内容 (chunk-specific content)
- Stream
 - 由一个SCTP端到另一个端点的**单向**逻辑通道
- Transmission Sequence Number (TSN)
 - 32-bit Sequence Number
 - SCTP分组中Chunk的标识
 - 由Chunk携带
- Stream Sequence Number (SSN)
 - 16-bit Sequence Number
 - Stream的标识
 - 有SCTP分组携带

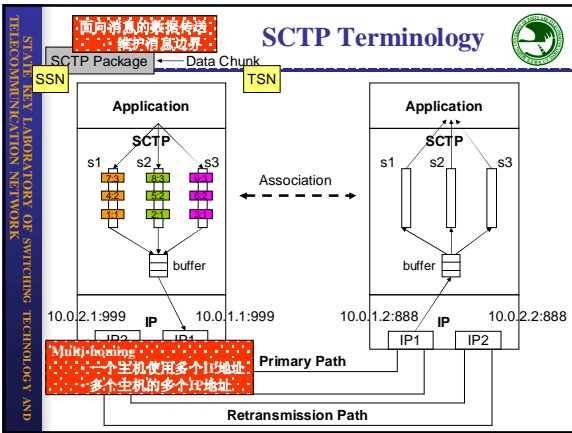
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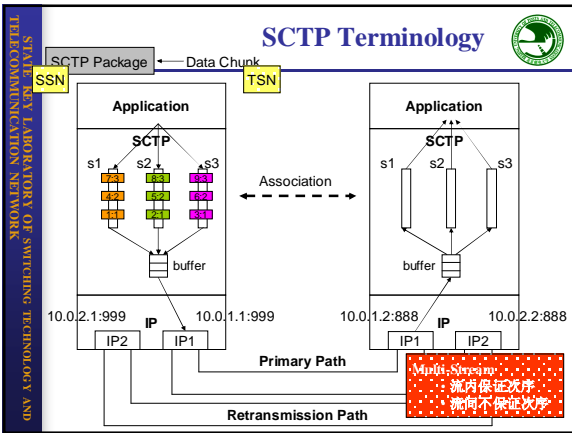
SCTP Terminology



- SCTP Association
 - 描述SCTP端点 (endpoint) 之间的关系
 - 以传送层地址“唯一”标识
 - 两个SCTP端点之间同时只能有一个Association
- Path
 - SCTP分组由Association的一个端点传送至另一个端点的路由
- Primary Path
 - 默认Path






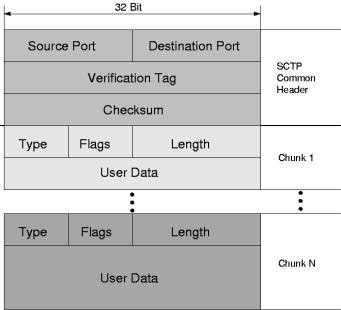


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SCTP Terminology




- SCTP Packets



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SCTP Terminology



ID Value	Chunk Type	SCTP Chunks	
0	- Payload Data (DATA)		Data Chunk
1	- Initiation (INIT)		Control Chunk
2	- Initiation Acknowledgement (INIT ACK)		
3	- Selective Acknowledgement (SACK)		
4	- Heartbeat Request (HEARTBEAT)		
5	- Heartbeat Acknowledgement (HEARTBEAT ACK)		
6	- Abort (ABORT)		
7	- Shutdown (SHUTDOWN)		
8	- Shutdown Acknowledgement (SHUTDOWN ACK)		
9	- Operation Error (ERROR)		
10	- State Cookie (COOKIE ECHO)		
11	- Cookie Acknowledgement (COOKIE ACK)		
12	- Reserved for Explicit Congestion Notification Echo (ECNE)		
13	- Reserved for Congestion Window Reduced (CWR)		
14	- Shutdown Complete (SHUTDOWN COMPLETE)		
15 to 62	- reserved by IETF		
63	- IETF-defined Chunk Extensions		
64 to 126	- reserved by IETF		
127	- IETF-defined Chunk Extensions		
128 to 190	- reserved by IETF		
191	- IETF-defined Chunk Extensions		
192 to 254	- reserved by IETF		
255	- IETF-defined Chunk Extensions		IETF预留

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SCTP特性

- 4-Way Handshake
- Multi-Stream
- Multi-Homing

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4-Way Handshake

- INIT
 - Number of streams
 - Available interfaces
- INIT-ACK
 - Number of streams
 - Available interfaces
 - Generate TCB (Transmission Control Block)
- COOKIE-ECHO
 - Return Cookie to server
- COOKIE-ACK
 - Verify Cookie
 - Allocate resources

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4-Way Handshake

SCTP **TCP**

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Multi-Streaming

- SCTP支持在每个association中使用多个Stream
- 在Association建立的过程中要进行Multi-Streaming的协商
- 解决队头阻塞的问题
 - 一个Stream内部的分组发送可以有序的
 - 多个Stream的分组间没有次序关系

Sender → [3 ghi] [2 def] [1 abc]

Receiver ← [3 ghi] [2 def]

针对1个Stream的情况

发出3个分组
分组1丢失

Sender → [Stream 0] [Stream n]


Receiver ← [Stream 0] [Stream n]

针对多个Stream的情况

不相关的分组可以在不同的Stream上传送

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Multi-Homing



- 建立Association（管理IP地址）
 - SCTP客户端使用多个IP地址
 - 此客户端在建立与服务器端的Association时，通过INIT Chunk将其所有的IP地址通知服务器端；
 - SCTP服务器端使用多个IP地址
 - 此服务器端在回复客户端的INIT Chunk时将在INIT-ACK中声明其所有的IP地址；
 - SCTP只需知道1个服务器端的IP地址就可以了
 - SCTP既支持IPv4地址，也支持 IPv6地址
 - 每个SCTP实例将每个对端的IP地址均作为一个“发送Path”
 - 在Association建立时将从中选择一个作为“Primary Path”
 - 如果在INIT中没有明确指明客户端的IP地址或是在INIT-ACK中没有明确指明服务器端的IP地址，则直接使用IP分组的源地址作为SCTP端点的IP地址

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Multi-Homing



- Path Monitoring
 - SCTP实例将监视Association中的所有“发送Path”
 - 如果某Path没有被用于传送数据（Data Chunk），则可以在此Path上发送HEARTBEAT chunks，对端则以HEARTBEAT-ACK chunk响应；
 - Path有两种状态：active/inactive.
 - 如果HEARTBEAT没有被响应或是数据重传达到一定次数，本端端点则认为对端端点不可达，并终止此Association

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Multi-Homing



- Path Selection
 - 每个SCTP实例将每个对端的IP地址均作为一个“发送Path”
 - 在Association建立时将从中选择一个作为“Primary Path”
 - 在重传时，一般要选定另一条Active的Path；
 - 当Path的状态改变时，SCTP用户将得到通知；
 - SCTP用户可以主动查询Path的状态
 - SCTP用户可以主动要求改变Primary Path

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SCTP高层接口

SCTP用户
Sctp
IP

SCTP用户 → Sctp
Sctp → SCTP用户

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SCTP高层接口

- SCTP用户 → Sctp
 - Initialize
 - Associate
 - Shutdown
 - Abort
 - Send
 - Set Primary
 - Receive
 - Status
 - Change Heartbeat
 - Request HeartBeat
 - Get SRTT Report (Smoothed Round-Trip Time)
 - Set Failure Threshold
 - Set Protocol Parameters
 - Receive unsend message
 - Receive unacknowledged message
 - Destroy Sctp instance

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SCTP高层接口

- Sctp → SCTP用户
 - DATA ARRIVE notification
 - SEND FAILURE notification
 - NETWORK STATUS CHANGE notification
 - COMMUNICATION UP notification
 - COMMUNICATION LOST notification
 - COMMUNICATION ERROR notification
 - RESTART notification
 - SHUTDOWN COMPLETE notification

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SCTP消息流程

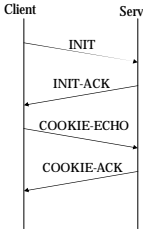
- SCTP Association建立
- 4-Way Handshake
- SCTP数据交换
- SCTP Association关闭
- 3-Way Handshake

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SCTP消息流程

• SCTP Association建立



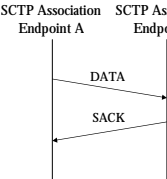
- INIT
 - Number of streams
 - Available interfaces
- INIT-ACK
 - Number of streams
 - Available interfaces
 - Generate TCB (Transmission Control Block)
 - Generate Cookie (MD5 or SHA1)
- COOKIE-ECHO
 - Return Cookie to server
- COOKIE-ACK
 - Verify Cookie
 - Allocate resources

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SCTP消息流程

• SCTP数据交换



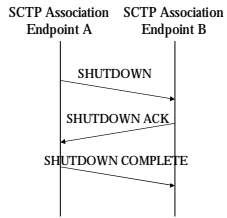
- TCP vs. SCTP
 - TCP
 - 发现接收序号有缺口
 - 等待缺口被填上, 才发送序号高于丢失数据包的数
 - SCTP
 - 发现接收序号有缺口
 - 仍会发送后面的数据

SACK: Selective ACKnowledgement

SCTP消息流程



• SCTP Association关闭



3-Way Handshake

1. 端点A接收到来自高层的SHUTDOWN原语
 1. 使本端点进入SHUTDOWN PENDING状态
 2. 不再接受上层的应用数据
 3. 只发送队列中剩余的数据
2. 端点A中所有未完成的数据被证实后
 1. A发出“SHUTDOWN”
 2. 端点A进入SHUTDOWN SENT状态
3. 端点B收到“SHUTDOWN”
 1. 进入SHUTDOWN RECEIVE状态
 2. 不再接受上层的应用数据
 3. 只发送队列中剩余的数据
4. 端点B中所有未完成的数据被证实后
 1. B发出“SHUTDOWN ACK”
5. 端点A发出“SHUTDOWN COMPLETE”，完成Association的关闭
